

Continuation of the Bermuda Testbed Mooring Activities

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LONG-TERM GOAL

The long-term goal of the Bermuda Testbed Mooring (BTM) program is to provide the oceanographic community a reliable deep-water platform for testing and developing new instrumentation and for the evaluation of acoustic and RF telemetry technologies. Scientific studies also utilize data collected from the BTM, particularly in conjunction with the U.S. JGOFS Bermuda Atlantic Time-series Study (BATS) program [1-7]. Additionally, the BTM has been used for groundtruthing satellite ocean color imager (SeaWiFS) data [8-9]. The mooring is located about 80 km southeast of Bermuda. Surface instruments have collected meteorological and spectral radiometric data from the buoy tower and measurements at depth have included: currents, temperature, bio-optical, chemical, and acoustical variables.

OBJECTIVES

Observations based on developments in instrumentation and other technologies have led to major advances in ocean sciences. Many innovative technologies involving computing, electronics, communications, and environmental sensing are being developed and will be beneficial for oceanography [10-11]. Our specific objectives for the present aspect of the BTM are to provide mooring design, fabrication and operations support for ongoing instrumentation development and related environmental measurements. The tasks required to meet these objectives include building replacement moorings, leading the field operations, organizing the cruise logistics, and working closely with other researchers who are using or plan to use the platform. We are in the process of designing a new buoy for the BTM under separate NSF funding. This activity complements the present study.

APPROACH

Figure 1 shows the most recent mooring configuration for the BTM. Our technical approach involves mooring turnarounds at 4-month intervals with yearly replacement of all mooring hardware. The mooring itself is a semi-taut surface design where the nylon section located below 2000m provides compliance for wave and current forces. The mooring is retrieved on each turnaround and returned to the Bermuda Biological Station for Research (BBSR) for instrument maintenance. A new anchor is used on each deployment.

WORK COMPLETED

- Deployment #12 was recovered on November 6, 1999. The mooring was refurbished and redeployed on December 5, 1999.
- Deployment #13 was recovered on May 27, 2000 and the mooring was refurbished at BBSR.
- Deployment #14 was installed on June 1, 2000 (see Figure 1).

The next turnaround is scheduled for November 2000.

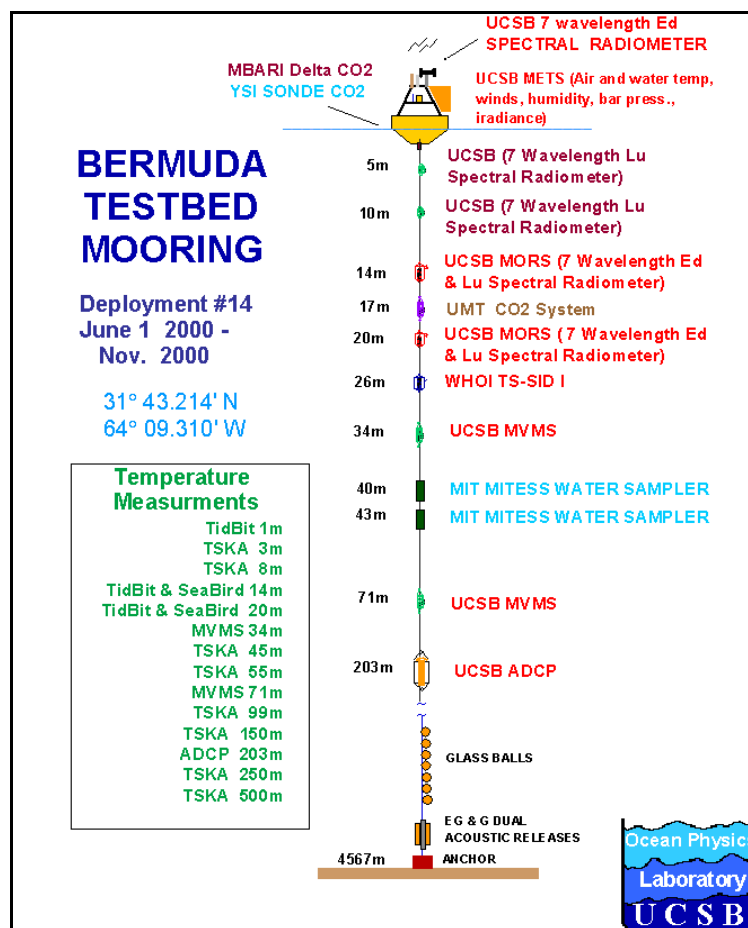


Figure 1. Bermuda Testbed Mooring configuration deployed June 1, 2000

RESULTS

Some of the key BTM results are summarized below:

1. Data obtained during passages of cold-core eddies have been used to estimate the role of such features on new production and carbon flux to the deep ocean [3-4]. One of the observed features contained the greatest values of chlorophyll observed during a decade of observations at the site (based on BATS historical database).
2. The dynamics of the upper ocean have been observed during transient re-stratification events and during passages of hurricanes and other intense storms [2].
3. During the BTM project, U.S. and international groups have tested new sensors and systems. These include new measurements of pCO₂, dissolved oxygen, nitrate, trace elements, several spectral inherent and apparent optical properties, and ¹⁴C for primary production.
4. Results of intercomparisons of currents obtained by three different instruments (VMCM, ADCP, and a new acoustic current meter) have been published [12].
5. Newly developed and tested spectral optical systems were successfully transitioned for coastal studies [13-15].

The BTM was on station from December 5, 1999 through September 2000. A turnaround is scheduled for early November 2000 to cover the winter and early spring (2001) period.

IMPACT/APPLICATIONS

The BTM provides the means to test new instruments through long term use in the deep ocean and through comparison with other sensors and techniques. New measurement systems and scientific results from the BTM project are leading to improved sampling relevant to global biogeochemical cycling and climate change. The BTM project has also been used for the education of several undergraduate students (6), graduate students (3 M.S. and 1 Ph.D. degrees granted) and post-doctoral fellows (3). In addition, over 200 UCSB undergraduates annually receive instruction based in part on the BTM activity. Over 20 refereed papers have resulted from the BTM program.

The list of instruments presently being evaluated on the mooring include the following:

- MIT Trace Metal Sampler (generations 1 and 2--several years' deployments) [16-17]
- UCSB Bio-optical Sensor Systems (several years' deployments of several sensor systems) [8]
- University of Montana CO₂ sensor (3 deployments)
- Datasonics acoustic modems were installed at 14 and 34 meter depths (3 deployments, 1 year)
- WHOI Time Series Incubation Device (TS-SID) (1 deployment) [18]
- YSI buoy mounted CO₂ and O₂ Sensor System
- MBARI buoy mounted delta CO₂ Measurement System

TRANSITIONS

Various scientists are using the data collected from the BTM for both instrumentation development and for science programs. The instrumentation investigators include:

Dr. Tommy Dickey of the University of California Santa Barbara has been funded under an NSF grant to use the BTM for testing a variety of new biooptical instruments [8]. He has installed ten or more instruments on each deployment. Dr. Dickey has also used the mooring as a platform for NASA-funded radiometry measurements in support of satellite ground-truth measurements.

Dr. Ed Boyle of MIT has deployed 2 generations of trace metal samplers on the BTM [16-17].

Dr. M. DeGrandpre, University of Montana, deployed his CO₂ sensor on the BTM in July 1999 for the first time. It has been deployed on two subsequent turnarounds.

Dr. Craig Taylor's Time Series Sample Incubation Device (measures a time series of primary production using Carbon 14 analysis; see [18]) was deployed for the first time in June 2000.

Dr. Ping Wu of YSI, under DOE funding, deployed the YSI Sonde – CO₂ and O₂ buoy mounted sensor system for its first open ocean deployment in June 2000.

Dr. Gernot Friedreich of MBARI, under NOPP O-SCOPE funding, deployed his buoy mounted delta CO₂ measurement system in June 2000.

RELATED PROJECTS

Mooring Operations in Support of the Bermuda Testbed Mooring Program – Subcontracted to WHOI from UCSB on an NSF grant.

Forty-one scientists from a variety of institutions have, or are using BTM data sets for modeling, observations or educational purposes.

The BTM has been used for groundtruthing of the NASA satellite ocean color imager (SeaWiFS) [8].

The National Ocean Partnership Program (NOPP) Ocean-Systems for Chemical, Optical, and Physical Experiments (O-SCOPE) has used the BTM for developing and testing new instrumentation [19-20].

The Southampton Oceanographic Centre's autonomous underwater vehicle (AUV) Autosub was operated in the vicinity of the BTM site in June 1999 [21].

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Note: Data reports are now available via the UCSB website: www.opl.ucsb.edu/btm.html for deployments 1-13 and deployments 1-11 are available on CD-ROM.